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The Development of Explanatory Economic Hypotheses for Monetary Management

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The Development of Explanatory Economic Hypotheses for Monetary Management

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THE DEVELOPMENT OF EXPLANATORY ECONOMIC HYPOTHESES FOR MONETARY MANAGEMENT 1/

In this paper we shall assume that the goal of policymakers is to make a rational choice. The use of expressions such as "rational choice" is fraught with difficulty. Frequently the use of such expressions drawn from our commonly-used language, may evoke markedly different concepts of the meaning of the term on the part of listeners or readers. 2/ In an attempt to forestall possible confusion, we shall proceed to carefully explicate how we plan to use the expression "rational choice" in our paper.

1/ The authors wish to express their thanks to Professor Edward Ames and Professor R. L. Basmann for their comments on this paper. The quality of the paper benefited from their comments and criticisms. However, the views expressed in the paper should not be construed as either representing or not representing the views on this subject of Professors Ames and Basmann. The authors take sole responsibility for the contents of the paper.

This paper along with the comments of Professor Ames who acted as discussant of the paper at the Southern Finance Association Meetings will appear in the Southern Journal of Business.

2/ Other examples are the statements, "The investment demand of the business sector is excessive." "Interest rates are at a dangerously high level.

Definition 1: Choice space

Let X, Y denote two quantities, and $X = \{x_1, x_2, \ldots\ldots,\}$ $Y = \{y_1, y_2, \ldots\ldots\}$ denote the set of magnitudes of X and Y, respectively. A choice space will be defined as the cartesian product $X \otimes Y$, where each ordered pair $(x_i, y_i) \in X \otimes Y$ represents an ordered pair of magnitudes of the quantities X and Y.

Definition 2: Attainable choice space

An attainable choice space is a subset of the cartesian product $X \otimes Y$ which contains those ordered pairs of magnitudes of X and Y which the policymakers may attain by taking some policy actions available to the policymakers.

Definition 3: Ordering relation on the attainable choice space

For any two ordered pairs (x_1, y_1), (x_2, y_2) in the attainable choice space, if a policymaker faced with a choice between (x_1, y_1) and (x_2, y_2), chooses (x_1, y_1), then (x_1, y_1) is preferred to (x_2, y_2). We shall denote this by $(x_1, y_1) > (x_2, y_2)$.

Postulate I: For any two ordered pairs (x_1, y_1), (x_2, y_2) in his attainable choice space, a policymaker can specify one of the following choices:

(i) $(x_1, y_1) > (x_2, y_2)$

(ii) $(x_2, y_2) > (x_1, y_1)$

(2) The policymaker specified one and only one of the two choices.

Postulate II: For any three ordered pairs (x_1, y_1), (x_2, y_2), (x_3, y_3) in his attainable choice space, if the policymaker specified:

$$(x_1, y_1) > (x_2, y_2)$$

and

$$(x_2, y_2) > (x_3, y_3)$$

then he specifies $(x_1, y_1) > (x_3, y_3)$

Definition 4: Rational choice

If Postulates I and II hold, then a rational choice by a policymaker consists of choosing that ordered pair of magnitudes (x_i, y_i) in his attainable choice space such that:

$$(x_i, y_i) > (x_j, y_j) \text{ where}$$

(x_j, y_j) is any other ordered pair in his attainable choice space.

To give an example of the above idea of rational choice let us take two proffered economic quantities the rate of unemployment (U) and the rate of change of the price level (P). The choice space for the policymaker consists of the cartesian product $U \otimes P$. Each ordered pair of $U \otimes P$ consists of a magnitude of the unemployment rate and a magnitude of the rate of change of the price level. For example, the ordered pair (4%, 2%) representing an unemployment rate of 4% and a rate of increase of the price level of 2% is one element of $U \otimes P$.

For any choice space the set of attainable ordered pairs will generally be limited. The attainable choice space will be delimited by factors such as the policy instruments available, the state of the economy, and the willingness of the policymaker to use the available policy instruments.

Definition 5: State of the economy

> The state of the economy consists of those conditions which are assumed to remain constant during the observation period but may or may not change in periods outside the observation period.

As an illustration, let us assume that the policy instrument is open market operations, and let us further assume that given the state of the economy, to every magnitude of an open market purchase or sale of Government securities there corresponds one and only one ordered pair (u, p) in the attainable choice space. If these ideal conditions of economic knowledge hold, then the process of rational choice on the part of the policymaker consists of choosing that ordered pair (u, p) from his attainable choice space such that no other ordered pair (u_j, p_j) is preferred by him.

Unfortunately, we do not possess such ideal knowledge. As economists, we cannot at present specify a one-to-one correspondence between magnitudes of a policy variable and ordered pairs such as (u, p). This opens the possibility that even if Postulates I and II hold, the policymaker may not succeed in making a rational choice. Suppose the policymaker orders two possible choices as $(u_1, p_1) > (u_2, p_2)$. On the advice of his research staff, he pursues a policy aimed at attaining (u_1, p_1). However, the results of his policy are represented by (u_2, p_2). The goal of the policymaker was to make a rational choice (i.e., to choose the magnitudes for the unemployment rate and the rate of increase of the price level attainable by him that he most preferred). However, given the outcome of his action, he did not succeed in making his rational decision.

One of the goals of economic research is to explain certain aspects of the economic system so that the persons charged with policy decisions may be advised of the possible impact of their actions on the real world structure of the economy. In an attempt to explain the operation of a segment of the economy, and in his advice to policy-makers, the economist formulates and asserts propositions.

For example, one group of advisors, let us call them Group I may assert:

(1) There has been an increase in the Federal Income tax rate.

(2) Interest rates are at or near historically high levels.

(3) The increase in the tax rate combined with the high level of interest rates implies that during the next three quarters there will be a sharp decline in the flow of total spending.

(4) The decrease in the flow of total spending will lead to a rise in the numbers of workers unemployed to 5 per cent of the labor force.

To prevent the danger of "overkill," Group I may recommend that the Federal Reserve engage in a policy aimed at reducing the level of market interest rates.

A second group of policy advisors, let us call them Group II may assert:

(1) If, over the next three quarters, the money stock increases at an annual rate of more than 4 per cent then the resulting rise in total spending will offset the restraining effect on total spending of the recent increase in the Federal Income tax rate.

(2) Given the present productive capacity of the economy and given the predicted growth rate of the productive capacity of the economy, the growth in aggregate demand resulting from an increase in the money stock at a greater than 4 per cent annual rate will result in an annual rate of increase of the consumer price index of 4.5 to 5.5 per cent.

To prevent the consumer price index from rising at such a rapid rate, the policy advisors in Group II may recommend that the Federal Reserve engage in a policy aimed at maintaining the growth rate of the money stock in a range of 3-4 per cent.

If research in the field of economics is to be of use to the so-called "makers of economic policy," then the economist must be able to tell the policymakers that if they perform a definite physical operation on the elements of a set of objects of experience [3] under specified conditions they may expect to observe a well-defined change in a segment of the real world.

Definition 6: Real World

The expression real world will refer to a structure composed of observable phenomena, objects of experience, and observable relations between objects of experience and experimental operations that may be performed on objects of experience.

Examples of a definite change in the real world might be such observations as: a change in the proportion of members of the labor force who are unemployed, a change in the output of goods and services, or a change in the number of houses constructed.

If a policymaker is informed by one of his advisors that:

"You should control the magnitude of quantity X,"

the astute policymaker should, and most likely will raise some questions about this advice. Among the questions he may ask are:

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[3] We shall not attempt to give a precise intensive definition of the term 'object of experience.' Philosophers have tried for many years to give a precise intensive definition to this term and the subject has been the source of intense controversy among philosophers. The general consensus of opinion among philosophers seems to be that an object of experience is something which lies in the field of our immediate senses or our field of perception. The typewriter used to type this sentence, the piece of paper on which the sentence is typed, the desk on which the typewriter is placed, are all objects of experience. Numbers, prices, marginal propensity to consumer, demand and supply are not objects of experience. For a discussion of the important and extremely difficult problem of specifying exactly what is an object of experience, the reader is referred to Bertrand Russell, An Inquiry into Meaning and Truth (Baltimore: Pelican Books, 1962), and Henry Margenau, The Nature of Physical Reality (New York: McGraw-Hill, Co. 1950).

(1) Of the possible policy actions which I might take, which one will be most likely to succeed in determining the magnitude of X at the level you specify?

(2) If I succeed in determining the magnitude of X, what impact will this have on the magnitudes of other economic quantities?

(3) What empirical evidence can you offer to me that if I take a definite policy action I will succeed in determining the magnitude of X and hence the magnitudes of other economic quantities? In other words, what confirming evidence can you offer for your asserted propositions?

In order to give an adequate answer to the three questions posed by the policymakers, an economist must assert his recommendations in the form of propositions that have empirical content. The policymaker is not primarily interested in propositions that express relations between abstract terms. He wants to know what operations to perform and how the performance of these operations affects the magnitude of other economic quantities.

Returning to our two groups of policy advisors, Group I has recommended that the policymakers should take action to reduce the level of interest rates, Group II has recommended that policy action be taken to keep the growth rate of the money stock in a range of 3-4 per cent. The policymakers know that they do not by their direct actions control either the general level of interest rates or the magnitude of the money stock. The members of the Board of Governors and the Presidents of the Federal Reserve Banks know that the set of operations which they may perform to attempt to achieve a change in one or more aspects of the real world are limited to:

(1) Open market purchase and sale of Government securities.

(2) Within limits, changes in the legal reserve requirements on demand and time deposits held by member banks.

(3) Changes in the discount rate.

(4) Changes in the maximum level of interest rates that commercial banks may pay on different classes of time deposits.

(5) Changes in margin requirements.

(6) Discussions with commercial banks, i.e. moral suasion.

For the policy recommendations of either Group I or Group II to be of any use to the policymakers, the advisors must be able to tell the policymakers what operation available to them they should perform and how to perform that operation. Group I must be able to explain to the policymakers what action available to them they should take to bring about "a decline in the general level of market interest rates." Likewise Group II must be able to explain to the open market committee what actions to take to achieve the goal of keeping the growth rate of currency and demand deposits held by the nonbanking public in a 3-4 per cent range.

As an illustration we take the position of Group II. The policymaker may ask "How do I go about determining the magnitude of the money stock?" Group II may answer in the following form:

A: The Monetary Authorities can determine the magnitude of the monetary source base.

B: Changes in the magnitude of the monetary source base are followed one month later by changes in the same direction of the magnitude of the money stock.

Conclusion Q: The monetary authorities can determine the magnitude of the money stock.

Let us symbolize the conjunction of proposition A and B by P (i.e. $A \cdot B \equiv P$). The argument form used by the advisor has the logical form: 4/

$$\begin{array}{l} P \supset Q \\ \underline{\vdash : \ P} \\ \therefore \ Q \end{array}$$

Which may be read, the proposition represented by P (in this case the conjunction of two propositions A and B) implies the proposition Q. We assign the truth value true to the proposition P therefore we assign the truth value true to the proposition Q.

To determine the conditions under which we shall assign a truth value to a proposition such as P which is composed of the

4/ An argument, as we shall use the term, is a series of statements such that at least one of the statements is advanced to substantiate another statement.

logical conjunction of two or more propositions we state the following criterion.

Criterion for Assigning truth values to a proposition formed by the logical conjunction of two or more propositions:

If P is a proposition where $P \equiv A \cdot B \cdot C \cdots$, and each $A \cdot B \cdot C \cdots$ is a proposition then we assign a truth value true to P if and only if we assign a truth value true to each A, B, C, ... In all other cases we assign a truth value false to P.

The grounds on which the advisor asserts that, Q: The monetary authorities can determine the magnitude of the money stock, are based on the assumption that we can assign a truth value true to the two propositions denoted by A and B. The logical argument form says nothing about the means by which we decide to assign truth values to the propositions A and B. This belongs to the technical and method part of any subject matter area such as economics. The logical argument form only asserts that if we assign a truth value true to both A and B and hence to P that we may use this valid deductive argument form to assign a truth value true to the conclusion Q of our argument.

Let us now proceed to examine in some depth the crucial problem of how a group of advisors might proceed to set up a criterion for assignment of truth values to propositions such as A and B.

One means by which we can proceed to set up standards for assigning truth values to propositions such as A and B is to give empirical content to the proposition by operationally defining the terms and relations appearing in the proposition.

Definition 7: Operational Definition

Operational definitions are statements which:

(i) give a definition to the terms of a proposition such that the elements included in the domain of definition of the term are objects of experience,

(ii) define the relations and operations of a proposition by experimental operations performed on objects of experience under definite initial conditions.

As an example let us take proposition A:

"The Monetary Authorities can determine the magnitude of the monetary source base."

To give empirical content to this proposition the terms "Monetary Authorities," "monetary source base," and the relation "can determine" must be given an operational definition.

Operational Definition 1: Monetary Authorities

The term Monetary Authorities includes all individuals who are either a President of a Federal Reserve District Bank or a member of the Board of Governors of the Federal Reserve System.

Operational Definition 2: Monetary Source Base

The monetary source base is defined in terms of the consolidated balance sheet of the Federal Reserve and the Treasury.

$$\text{Monetary source base} = P + U + TC - (g + f + o + c)$$

P = Federal Reserve Credit

U = Gold stock

TC = Treasury currency outstanding

g = Treasury deposits at the Federal Reserve Banks

f = foreign deposits at the Federal Reserve Banks

o = other liabilities plus net worth minus other assets in the consolidated balance sheet of the Reserve Banks

c = Treasury cash holdings

Table 1

CALCULATION OF THE SOURCE BASE - JUNE 1968

Monthly Averages of Daily Figures

(Millions of Dollars)

Sources of Base

Federal Reserve Credit:	
Holdings of Securities	+51,396*
Discounts and Advances	+ 705
Float	+ 1,712
Gold Stock	+10,369
Treasury Currency Outstanding	+ 6,744
Treasury Deposits at Federal Reserve	- 960
Treasury Cash Holdings	- 973
Other Deposits and Other Federal Reserve Accounts	- 177
Source Base	68,816

* Includes acceptances of $90 million not shown separately.

Federal Reserve holdings of Government securities as a per cent of monetary source base 74.7%

The relation "can determine" is very imprecise and could possibly be rendered "there exists an operation which the Monetary Authorities can perform which will determine the magnitude of the monetary source base." This "there exists" statement has the form of an existential statement. One of the logical characteristics of this form of statement is that it can never be falsified. The advisor who asserts such a proposition can feel quite safe that his assertion can never be refuted. However, this feature is not very useful for policy advice. The policymaker does not want to be told "there exists an operation by which you can determine the magnitude of the monetary source base," he wants to know what that operation is and how it should be performed.

To give empirical content to his assertion, the economist may replace the "there exists an operation" with an operational definition of the operation. Precisely, the operation of purchase and sale of Government securities.

The proposition might now be reformulated:

> "The Monetary Authorities by purchase or sale of Government securities can determine the magnitude of the monetary source base."

The policymaker may now reply to the economist that now that he has interpreted the term monetary source base and the operation which the policymaker might perform to affect the magnitude of the source base, what does he mean that the Monetary Authorities can determine the magnitude of the base? Surely such items as float, gold flows, and Treasury cash policy also influence the magnitude of the base.

The economist must now state the necessary and sufficient conditions such that under these conditions, by performing the operation of purchasing or selling on the objects called Government securities, the Federal Reserve authorities can determine the magnitude of the economic quantity the monetary source base.

Necessary and Sufficient Conditions:

> The Federal Reserve System holds a large enough volume of Government securities and there is a large enough volume of Government securities held by the public so that by purchase or sale of Government securities the Monetary Authorities may offset any change in the magnitude of the source base caused by other items which constitute the base.

Objective Criterion:

> To objectively establish if the necessary and sufficient conditions hold, compare the dollar volume of Government securities held by the Federal Reserve System and the public with the dollar volume changes in other items of the monetary source base.

The economist has now provided an empirical interpretation of the terms in his proposition, specified a definite operation the Monetary Authorities can perform, specified the necessary and sufficient conditions for assigning a truth value true to his proposition, and has provided an objective criterion for determining whether these conditions hold. He has now established a criterion for, at any point in time determining whether to assign the truth value true or the truth value false to proposition A.

As we remarked earlier, the assignment of a truth value true to the conclusion of the argument form:

$$\begin{array}{l} \quad P \supset Q \\ \vdash : \underline{\;P\;\;\;\;\;} \\ \quad \therefore Q \end{array}$$

depends not only on being able to assign a truth value to proposition A but also on being able to assign a truth value to proposition B. The assignment of a truth value true to proposition A is a necessary but not a sufficient condition for assigning a truth value true to the conclusion Q. We must also be able to determine the truth value to be assigned to proposition B.

Perhaps this point will be clarified if we look closely at the relationship between propositions A and B and the conclusion Q. Proposition A asserts that the monetary authorities can, by a definite action on their part, determine the magnitude of the source base. Suppose, using our objective criterion, we decide that at a point in time this proposition expresses a true representation of the relation between Federal Reserve open market operations and the source base (i.e., we assign a truth value true to A). Does this necessarily imply that the monetary authorities can determine the magnitude of the money stock?

Clearly the answer is "No." To establish a logical connection between the actions of the monetary authorities and the money stock we need to determine the truth value of proposition B which asserts a relation between changes in the base and changes in the money stock.

Let us take a close look at B which asserts:

> "Changes in the magnitude of the monetary source base are followed one month later by changes in the same direction of the magnitude of the money stock."

B has the form of an economic law. It is a universal statement that epxresses a relationship between ordered pairs of magnitudes of the monetary base and the money stock.

Let: (1) b represent a variable that ranges over the set of magnitudes of the monetary source base, i.e. the range of $b = \{b_1, b_2, b_3, \ldots\}$ where each $b_i \varepsilon b$ is a magnitude of the base.

(2) m represent a variable that ranges over the set of magnitudes of the money stock, i.e. the range of $m = \{m_1, m_2, m_3, \ldots\}$ where each $m_i \varepsilon m$ is a magnitude of the money stock.

B may now be expressed in the symbolic form:

$$1.1 \qquad (b, m)\ (\theta b_t \supset \Psi\ m_{t+1})$$

which may be read, for every pair of magnitudes of the base and the money stock, a change in the magnitude of the base in period t is followed by a change in the same direction in the magnitude of the money stock in period t + 1.

The conclusion that the monetary authorities can control the magnitude of the money stock by controlling the magnitude of the monetary base via open market operations depends on the truth value assignment given to this economic law. The policy advice offered the policy-maker that if they take open market actions to reduce the growth rate of the base they will succeed in slowing the growth rate of money depends upon B representing a true relationship between changes in the base and the money stock. The prediction of the outcome of the action taken by the policymakers, using the argument we have advanced in our example, depends on the truth of B. However, the actual outcome of the action does not necessarily depend on the truth value of B.

A prediction statement that a change in the magnitude of the monetary base in a specific month, say December, 1968 will be followed by a change in the same direction in the magnitude of the money stock in January, 1969 is based on the assumption of the assignment of a truth value true to the statement function 1.1.

Let us take a close look at the form we have chosen to express B. In the form

$$(b,\ m)\ (\theta\ b_t \supset \Psi\ m_{t+1})$$

we have expressed what is called in logic a propositional function or sentential function. The symbols b and m are variables ranging over a set of values. [5] What we are asserting by B is that given a change in the magnitude of the base we will observe in the following month a change in the same direction in the money stock. We use this relation to predict the result of a change in the base. What we actually observe are changes in the monetary base in a **specific** month and then we observe the movement in the magnitude of the money stock in the following month, i.e. did money increase, decrease, or remain unchanged? In other words we observe specific instances of the general law asserted by B. Given our definition of the terms money stock and monetary source base, and our method of determining if the relation asserted by the proposition holds, we may determine for each specific instance of the occurrence of a change in the magnitude of the base whether a change in the same direction of the money stock occurred in the following month.

We shall now give two schemas for assigning truth values to economic laws of this form.

> Let: b_1 and m_1 refer to specific magnitudes of the base and the money stock. In our example, b_1 might be the magnitude of the base in November, 1965 and then m_1 would refer to the magnitude of the money stock in December, 1965.

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[5] See Alfred Tarski, Introduction to Logic and the Methodology of the Deductive Sciences, (New York: Galaxy Books, Oxford University Press, 1965), pp. 3-12.

Confirmation schema

$$(b, m)\ (\theta\, b_t \supset \Psi\, m_{t+1}) \supset (\theta\, b_1 \supset \Psi\, m_1)$$

$$(\theta\, b_1 \cdot \Psi\, m_1) \supset (\theta\, b_1 \supset \Psi\, m_1)$$

$$\theta\, b_1$$

$$\Psi\, m_1$$

$$(\theta\, b_1 \supset \Psi\, m_1)$$

$$\therefore\ (b, m)\ (\theta\, b_t \supset \Psi\, m_{t+1})$$

In the confirmation schema we reason that if the economic law $(b, m)\ (\theta\, b_t \supset \Psi\, m_{t+1})$ is to be assigned a truth value true then each specific instance $(\theta\, b_1 \supset \Psi\, m_1)$ should be assigned a truth value true. We investigate the relation between specific instances of the law. For example, if θb_1 represents a change in the magnitude of the base in November, 1965 and we observe that $\Psi\, m_1 \equiv$ a change in the magnitude of the money stock in the same direction occurred in December, 1965, then this represents one confirming instance of the economic law. A derivable consequence of the universal proposition $(b, m)\ (\theta\, b_t \supset \Psi\, m_{t+1})$ was shown to be in good agreement with empirical evidence.

Falsification schema

$$(\theta b_1 \cdot \sim \Psi m_1) \supset \sim (\theta b_1 \supset \Psi m_1)$$

$$\sim (\theta b_1 \supset \Psi m_1) \supset \sim (b, m) (\theta b_t \supset \Psi m_{t+1})$$

$$\theta b_1$$

$$\sim \Psi m_1$$

$$\sim (\theta b_1 \supset \Psi m_1)$$

$$\therefore \sim (b, m) (\theta b_t \supset \Psi m_{t+1})$$

In the falsification schema, like the confirmation schema, we reason that if we are to assign a truth value true to our economic law then each specific instance of the law should be in good agreement with empirical evidence. If for a specific instance, the occurrence of a change in the magnitude of the monetary base is not followed one month later by a change in the same direction of the magnitude of the money stock (i.e. $\sim\Psi m_1$) then we assign the truth value false to the relation $(\theta b_1 \supset \Psi m_1)$, i.e. $\sim (\theta b_1 \supset \Psi m_1)$. Since a consequence that the economic law predicts would not occur has in fact been shown to be in good agreement with empirical observations, we assert that the universal statement "for every pair of magnitudes (b, m) of the base and the money stock, a change in the base is followed one month later by a change in the magnitude of the money stock ($\theta b_t \supset \Psi\ m_{t+1}$) is not in good agreement with empirical evidence and we assert $\sim(b, m)\ (\theta b_t \supset \Psi\ m_{t+1})$.

One method for setting up a criterion by which to assign truth values to propositions such as B is to view the proposition as an hypothesis about the relation between magnitudes of two economic quantities and to use the methodology of duductive testing of an hypothesis as a criterion for assigning truth values to the proposition.

The deductive testing of an hypothesis consists of:

(1) Deriving logical consequences of these hypotheses which may be subjected to falsification by a set of empirical observations,

(2) The specification of operations to be performed upon the data.

(3) The performance of the well-defined operations on the relevant body of data.

(4) The reporting of the results of the performance of these operations.

The empirical testing of economic hypotheses is carried out under certain directive principles or methodological rules of the game of empirical science. 6/ Among these ground rules are the following:

6/ Directive principles are methodological rules. They are not principles which can be shown to be true or false by any appeal to logical or empirical evidence. They are conventions or rules of the game of empirical science accepted by the majority of the persons engaged in empirical research simply because such rules have been found to be extremely useful in promoting the advancement of empirical science.

(1) All evidence relevant to the potential falsification of an hypothesis must be considered.

(2) The data used and the operations performed on this data to confirm or falsify the hypothesis must be clearly and fully reported so that other investigators may repeat the operations.

In our example, this method would involve deriving from,

B: "Changes in the magnitude of the monetary source base are followed one month later by changes in the same direction of the magnitude of the money stock"

logical consequences of the proposition and subjecting these consequences to an empirical test. We would be asserting that these statements about real world objects and relations between these objects were a necessary consequence of our proposition B.

As an illustration we might derive the statement:

S.1 "There is a positive correlation between changes in the magnitude of the monetary source base and changes in the magnitude of money stock one month later."

S.1 would be viewed as a derivable consequence of B. We would symbolize this by:

$$(b, m)\ (\theta b_t \supset \Psi\ m_{t+1}) \supset S.1$$

S.1 would serve as the potential falsifier of the relation between the base and the money stock asserted by B, i.e.

$$\sim S.1 \supset \sim (b, m) (\theta\ b_t \supset^{\Psi} m_{t+1})$$

We must now look in somewhat greater detail at our two schemas. Especially the form of our confirmation schema. Notice that we said this was a schema for assigning the truth value confirmed to the proposition B, we did not assign the truth value true to the proposition B using this schema. If we assign a truth value true to S.1 and then proceed to assign a truth value true to B we have committed a logical fallacy known as affirming the consequent. It is necessary for the truth of B that S.1 be assigned a truth value true, but it is not sufficient. Because S.1 is shown to be in good agreement with the performance of certain well-defined empirical tests it does not logically follow that B must be true. 7/

The reader may recall we stated that the actual outcome of an open market purchase or sale of Government securities by the Monetary Authorities does not necessarily depend on the truth value assignment to B. It may be the case that by empirical testing B we assign a truth value false to B. Still, a change in the monetary base may be followed one month later by a change in the same direction in the magnitude of the money stock. Our ability to predict the outcome of a given action may be quite good although our explanation of why, given the

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7/ This point can best be illustrated by a simple example. Take the proposition "If X is a whale, then X is a mammal." Suppose for an object α we determine that α satisfies the criterion for being a member of the class of objects denoted by the term "mammal." We assert $\vdash$: α is a mammal. We then proceed to assert α is a whale. It may be the case that α is a whale, but it may also be the case that α is some other type of mammal.

action, the outcome occurred may be false. [8]

The falsification schema is analogous to a valid argument form in logic called the modus tollens. If S.1 is a logical consequence of B, then it is necessary that S.1 be in good agreement with empirical observations. If we falsify S.1 (on the basis of our empirical test we decide to assign a truth value false to S.1) then we must, according to the rules of logic, assign a truth value false to B.

The forms of our two schemas, which we have presented as one possible method of determining the truth value to be assigned to a proposition such as B, have important consequences for assertions we can make about the truth value assignments made to B.

By deductive testing of an hypothesis we cannot prove the hypothesis to be true. We can only say that on the basis of repeated testing, the logical consequences of the hypothesis have been shown to be in good agreement with a finite set of empirical observations. A necessary condition for our hypothesis to be true is that all of the consequences which it logically implies be shown to be in good agreement with empirical observations. This condition is only necessary and not sufficient. The possibility remains that consequent of our implication may be true and the antecedent clause false. The assignment of a truth value true to propositions of the form of B, under the schema we have called the confirmation schema, are conditional truth value assignments.

8/ See Bertrand Russell, An Inquiry into Meaning and Truth (Baltimore: Pelican Books, 1962), pp. 214-215.

The assignment of a truth value true is conditional upon B being repeatedly confirmed by confronting its logical consequences with empirical evidence. However, one disconfirming instance can falsify our hypothesis. If one of the derived consequences of our hypothesis is shown to be not in good agreement with empirical evidence, then one of the conditions necessary for asserting the truth of the hypothesis is violated.

Let us now return to our policymakers and their economic advisors. The advisors from Group II have asserted two propositions. The first of these, which we denoted by A, expresses a relation between an action which the monetary authorities can perform on objects of experience and the magnitude of an economic quantity, the monetary source base. The second proposition, B, expresses a relation between changes in the magnitudes of two economic quantities, the monetary source base and the money stock. From the logical conjunction of these two propositions, the advisors deduce the conclusion that the monetary authorities can determine the magnitude of the money stock.

The policy advisors have explained to the policymakers that their grounds for asserting the truth of their conclusion depends upon the assignment of truth values true to A and B, and have shown their criterion for determining the truth value assignments to be made to A and B. Most importantly, they have clearly pointed out that the assignment of a truth value true to proposition B--the relation between the base and money stock--is a conditional truth value assignment.

As support for assignment of a truth value true to B the economist offers the evidence that one of the logically derived consequences of his hypothesized relation between the monetary base and the money stock, a consequence that must be in good agreement with empirical observations for assigning a truth value true to the hypothesis, has been shown to be in good agreement with a finite set of observations. Specifically, the economist has found, for a finite set of observations, a positive correlation between changes in the magnitude of the monetary base and changes one month later in the magnitude of the money stock.

The policymaker may now reply that the conclusion reached by the advisor that the Federal Reserve can control the magnitude of the money stock is a very important conclusion. It is especially interesting in light of the fact that the economist has shown how the Monetary Authorities, by a well-defined and available action on their part, can determine the magnitude of the monetary source base. However, the policymaker remains reluctant to base his policy decisions on the assumption that the conclusion of the argument of the advisor is true. He points out to the advisor that the truth value of his conclusion depends on the truth value of the asserted relation between changes in the magnitude of the base and changes in the magnitude of the money stock.

He recognizes that the evidence offered for the proposition fails to refute the assertion that it is a true representation of the relation between the important economic quantities. The canny policy-maker points out that although for the observation period there is a large and significant positive correlation between the changes in the magnitudes of the two quantities, this does not necessarily imply the truth of the asserted relationship between them. This may only be a spurious correlation, i.e., the high positive correlation may not represent any cause and effect relation. Also, he may continue, other economic research indicates that other factors enter into the determination of the magnitude of the money stock. For example, the reactions of the commercial banks and the public to changes in the supply of base money.

The economist may attempt to provide further evidence for his asserted relation between changes in the supply of base money and changes in the magnitude of the money stock by:

(1) using a different period of sample data and repeating his test of calculating the correlation between the changes in the magnitudes of the two economic quantities and/or

(2) deriving other logical consequences of his hypothesis that act as potential falsifiers of the hypothesis and confronting them with empirical observations.

Alternatively, he may decide to construct a more extensive, well-developed hypothesis to explain the determination of the magnitude of the money stock. Such an hypothesis might consist of several propositions which express a proposed representation of the behavior of commercial banks and the public. The hypothesis might consist of a set of definitional relations that define the basic terms of the hypothesis (for example, the terms "money," and "monetary base"), a set of propositions that represent part of the behavior of commercial banks, and a set of propositions that represent part of the behavior of the public. The conjunction of these sets of basic definitions and propositions form a mechanism that is hypothesized to represent the process by which the magnitude of the money stock is determined. 9/ In many such proffered representations of economic phenomena the terms and relations of the hypothesis are represented by mathematical symbols and relations.

The creation of more fully developed hypothesis has the advantage of offering the possibility of broadening our understanding of the process by which the magnitude of an economic quantity such as the money stock is determined. Our original proposition B only asserted a relation between changes in the magnitude of the source base and lagged changes in the money stock. In an hypothesis such as the Brunner-Meltzer non-linear hypothesis, a direct connection between the base and the money stock may be derived and the manner in which other factors influence changes in the money stock may be explicitly included in the formulation.

9/ As an example of such an hypothesis see Karl Brunner and Alan Meltzer, "Liquidity Traps for Money, Bank Credit, and Interest Rates," Journal of Political Economy, January/February, 1968.

Merely formulating a more elaborate hypothesis does not by itself necessarily broaden our knowledge of the economic mechanism. If such an hypothesis is devoid of empirical content, then for policy advice, it may be less desirable than a much less elaborate hypothesis. The creation of a more fully developed hypothesis opens the possibility of broadening our understanding, it does not insure that this goal will be realized. The process of providing confirming evidence for a hypothesis consisting of a number of propositions linked together is the same as for our simple example. It consists of deriving logical consequences of the hypothesis that may be falsified by confrontation with empirical observations.

An explanatory economic hypothesis is confirmed or falsified by confronting derivable propositions of the hypothesis with empirical evidence. Such hypotheses are never finally proven true. By repeatedly testing previously derived consequences of the hypothesis with new data, and by deriving new testable propositions from the hypothesis and confronting these propositions with empirical observations, we may increase the degree of confirmation of the hypothesis. The confirmation or falsification of a proposed explanation of economic events is always relative to the evidence used. Additional observations, refinement in existing techniques of testing making possible the testing of additional consequences of the theory, or improvements in the methods of collecting data may alter the conclusions of previous tests.[10]

10/ Orcutt, Watts and Edwards point out some of the difficulties involved in using present aggregate data, such as national accounts data, in rejecting economic hypotheses and discriminating between alternative hypotheses. G.H. Orcutt, H.W. Watts, and J.B. Edwards, "Data Aggregation and Information Loss," American Economic Review, September, 1968, pp. 773-787.

A good example of the effects of a change in the data caused by refined methods of observation or errors in observation on the results of mathematical models is offered by Oskar Morgenstern. 11/ Using a three-equation model, Morgenstern shows the changes in the solutions of the equations which result from different assumptions about errors of observations in the variable coefficients of the three-equation model. Assuming only a $\pm 10\%$ error in all coefficients of the model, produces a deviation of the order of + 42% and - 35% in the solution values of the equations of the model. Extension of the model to a greater number of equations would make the situation worse.

Over time, an hypothesis that may have been confirmed by all previous tests may have some of its derivable consequences disconfirmed by empirical tests. This may lead to reformulation of the hypothesis or the construction of a new hypothesis which explains the same set of events as the previous hypothesis and also explains the newly discovered phenomena.

Having broadly outlined the concept of an explanatory economic hypothesis we shall now proceed to discuss in greater detail two important parts of the construction and empirical testing of such a hypothesis. These are (1) the statement of initial conditions, and (2) the quantitative foundations of economic hypotheses.

11/ Oskar Morgenstern, On the Accuracy of Economic Observations, (2nd ed.; Princeton: Princeton University Press, 1963), pp. 110-114.

Initial Conditions

An economic hypothesis is put forward as a proffered representation of the mechanism by which changes in magnitude of one set of economic quantities (frequently called exogenous variables) lead to changes in the magnitude of another set of economic quantities (frequently called endogenous variables). Such change is assumed to take place against some invarient background or structure of the economy.

The background or structure of the economy is specified by the statement of background or initial conditions for the hypothesis. Although they are seldom explicitly stated, implicit in every economic hypothesis is the assumption of these initial conditions.

As an example, we offer some statements from an explication of one form of the 65-70 equation F.R.B.-M.I.T. Econometric Model. 12/

> The actual specification of the model reflects the judgment that there have been very few, if any, periods of demand inflation (aggregate demand greater than the short-run production capacity of the economy) in the United States since the Korean War. (p. 124)
>
> The critical implication of a model where factor proportions are variable only before capital is put in place is that the short-run elasticity of investment expenditures, with respect to once-and-for all changes in quasi-rents, is unlikely to exceed the long-run elasticity. (p. 128)
>
> The putty-clay CES aggregate long-run production function implies that at every point in time there exists a stock of capital of various vintages and for each vintage, the output/labor ratio is fixed. It is further assumed that the stock will be utilized in order of decreasing productivity until aggregate demand is satisfied. (p. 132)
>
> Therefore, assuming no significant variation in transactions costs, the equilibrium ratio of money demanded to transactions is related to the interest obtainable on short-term assets. (p. 137)

12/ Robert H. Rasche and Harold T. Schapiro, "The F.R.B.-M.I.T. Econometric Model: Its Special Features," American Economic Review, May, 1968, pp. 128-149.

> On the supply side, our basic hypothesis is that savings institutions set the rate of interest payable on their deposit liabilities and then meet any reasonable demand for these deposits. (p. 141)

A given explanatory economic hypothesis is designed to explain a set of economic events under a specific set of initial conditions. A change in one or more of these initial conditions will alter the derivable consequence of a proffered hypothesis. This will lead to a change in the set of observation reports that form the set of potential falsifiers of the hypothesis. An empirical observation that, under one set of initial conditions may be considered as evidence against the hypothesis, may given a change in one or more of these initial conditions, no longer be regarded as a falsifier of the hypothesis.

The specification of a set of initial conditions for a hypothesis, the specification of the effect of a change in one of these conditions on the derivable consequences of the hypothesis, and the empirical confirmation of these initial conditions is one of the most difficult parts of scientific inquiry. [13/] However, this is a very important aspect of scientific inquiry, both for the testing of hypotheses and for the use of these hypotheses as predictive devices. Over time the structure of the economy may change and this change may have an effect on the derivable consequences of a model. If the full structure of the model, including the relevant initial conditions under which it is proported to be a model of a segment of the economy, is not fully specified, then the predictive power of the model may be far from satisfactory.

13/ See Ernest Nagel, The Structure of Science (New York; Harcourt, Brace and World, Inc., 1961), pp. 30-32.

To illustrate the above points we shall now disucss a simple example.

EXAMPLE

T: Commercial banks borrow short-term funds at the lowest possible cost.

I_1: Commercial banks may borrow funds, at short-term in the Federal funds market.

I_2: Commercial banks may borrow funds short-term from the Federal Reserve Banks.

I_3: Commercial banks view Federal funds and borrowing at the discount window of Federal Reserve Banks as alternative sources of short-term funds.

I_4: The Federal Reserve Banks set the discount rate and then allow commercial banks to determine the amount of funds borrowed at that rate.

The conjunction of T with the set of initial conditions I_1, I_2, I_3, and I_4 forms a simple explanatory economic hypothesis. The purpose of the hypothesis is to explain the short-term borrowing behavior of commercial banks. The proposition denoted by T cannot be directly tested. To test the proposed explanation of this aspect of bank behavior, we proceed to derive, from the conjunction of T and the initial conditions, propositions which may be falsified when confronted with empirical observations.

One potential falsifier of the hypothesis might be of the following form:

Let: r_f = effective rate on Federal funds

r_d = Federal Reserve discount rate

$$b = \frac{\text{commercial bank borrowing at Federal Reserve Banks}}{\text{commercial bank borrowing of Federal funds}}$$

Potential falsifier 1: If $\left(\frac{r_f}{r_d}\right)_{t+1} > \left(\frac{r_f}{r_d}\right)_t$

then $b_{t+1} > b_t$

Our potential falsifier states that if the numercial value of ratio of the effective rate on Federal funds to the discount rate in period t + 1 is greater than the numercial value of the same ratio in period t, then we would expect to observe that the numerical value of the ratio b in period t + 1 is greater than the numerical value of b in period t. Having derived this proposition we now proceed to search for a set of data with which it may be confronted.

We now return to the crucial role of the initial conditions. The proposition which is to act as a potential falsifier of our hypothesis has been derived, not solely from the proposition T, but from the conjunction of T and the set of initial conditions $I_1 - I_4$. One of the functions of the initial conditions is to limit the set of observation statements that may serve as potential falsifiers of the hypothesis. For example, I_2 limits the class of commercial banks on which observations should be made. Only member banks of the Federal Reserve System have access to the discount window. I_1 forms a further limitation on the class of commercial banks. Due to the institutional structure of the Federal funds market, only large commercial banks borrow in the Federal funds market. A set of observations on small nonmember commercial banks would therefore not constitute evidence either for or against our derived proposition.

In our search for empirical observations with which we may confront our potential falsifier, we find that there is a series of data which is asserted to represent the real world terms appearing in our proposition. By being readily available to the public, it also satisfies our directive principle of the availability of data so other investigators may repeat our procedure. The Federal Reserve System regularly publishes data on the effective Federal funds rate, the discount rate, and for a sample of 46 large commercial banks borrowings of Federal funds and borrowings from the Federal Reserve Banks.

Suppose that using the data available in the Federal Reserve <u>Bulletin</u> we proceed to test our proposed explanation of bank borrowing behavior; and in a period of time we find that although

$$\left(\frac{r_f}{r_d}\right)_{t+1} > \left(\frac{r_f}{r_d}\right)_t$$

that $b_{t+1} < b_t$. Can we use this result as a falsifier of our theoretical proposition T? We can use this empirical test as evidence against T if and only if we can show that there is evidence that conditions $I_1 - I_4$ held during this period of time. We repeat again that the proposition which serves as a potential falsifier was derived from the conjunction of $I_1 - I_4$ and T. If we alter one of the initial conditions we will alter the derivable consequences of our hypothesis.

As an example, if we alter I_4 we would derive a different consequence of our hypothesis. If we find that over the period of time in which the evidence appeared to refute our hypothesis, the Federal Reserve Banks set the discount rate but did not allow commercial banks to determine the volume of borrowings, then we would not expect the same result as during a period in which I_4 held. Our empirical test will serve as a falsification of the assertion that our hypothesis, the conjunction of $I_1 - I_4$ and T, represents an explanation of a specific set of economic phenomena. It does not falsify the proposition that "Commercial banks borrow short-term at the lowest possible cost."

Quantitative Foundations

Many proffered representations of economic phenomena take the form of a mathematical model. Such a representation presents a system of mathematical equations connecting the terms of the hypothesis in a definite mechanism that attempts to represent the process by which the magnitude of certain economic quantities are determined. The structure of mathematics provides a very powerful analytical tool, the use of which has helped to advance knowledge in many fields of empirical science. However, the field of mathematics is not an empirical science. Mathematics is concerned with numbers and the operations which may be performed on numbers. Modern mathematical logic is a branch of mathematics and logic which attempts to impart substance to the concept of number as something on which certain logical operations may be performed. The terms natural number, rational number, and real number are given precise meaning within the framework of an axiomatic system called number theory. Also, within these mathematical structures certain logical operations such as +, -, x, ÷, are defined, and theorems are derived concerning the performance of these operations on numbers. There is no necessary empirical counterpart to the abstract entities called numbers, and no necessary empirical counterpart to the relations $<$ and $=$ between numbers; and there is no necessary empirical counterpart to the operations symbolized by +, -, x, ÷, performed on numbers.

Once we use numbers and operations performed on numbers in the testing of an empirical hypothesis, we have made a subtle passage from the real world into the space of abstract concepts. Numbers are not objects of experience. The use of numbers and operations performed on numbers in the confirmation or falsification of empirical propositions assumes the confirmation of another hypothesis. This hypothesis may be called the hypothesis of measurement. Broadly defined, this hypothesis asserts the proposition that the numbers used represent sets of objects of experience, and the relations between and operations performed on these numbers represent relations between and operations that may be performed on the sets of objects of experience that are represented by the numbers.

A vital underlying assumption of every test of an empirical hypothesis where the testing involves the use of numbers is that there is strong confirming evidence for the hypothesis of measurement. If the hypothesis of measurement is falsified, then the evidence adduced by use of the numerical data cannot be used as evidence for the falsification of the theoretical explanation advanced by the hypothesis it is used to test.

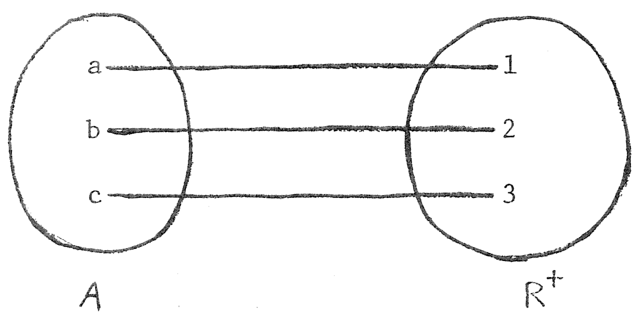
Measurement conceived of in this manner is not just the generation of a series of numbers. Numbers and mathematics are useful tools in empirical science because, in some cases, numbers can be used to represent sets of objects of experience, and the relations between these numbers and the mathematical operations such as addition performed on the numbers assigned to sets of objects of experience can be used to represent relations between and operations performed on the sets of objects of experience represented by the numbers. Unless we know what the numbers represent, what observable relation between sets of objects is represented by the numbers, and what experimental operation is isomorphic to the mathematical operations used, the use of mathematics in empirical science is at best useless, and at worse positively misleading.

Alternatively, the process of measurement may be viewed as a problem of establishing a one-to-one mapping from the space of objects of experience to the number space.

Let: $A = \{a, b, c\}$ where a , b, c are objects of experience

R^+ = set of positive real numbers

Let: $g: A \rightarrow R^+$ represent a mapping from the space of objects of experience into the space of positive real numbers.



Under the mapping $g\colon A \to R^+$ to each element of A is assigned a positive real number which represents that object. The object a is represented by the positive real number 1, the object b by the positive real number 2, and the positive real number 3 represents the object c.

One possible use of the numbers assigned to each of the objects of experience might be to act as a representation for the objects in the space A. This is the process followed in football or baseball where to each player is assigned a specific number which identifies that player. Because Tim McCarver, a catcher for the St. Louis Cardinals, has number 15 on his uniform and Bob Gibson, a pitcher for the Cardinals, has number 45 on his uniform does not represent any ordering relation between Gibson and McCarver. For example, some ardent baseball fans might assert that Gibson is three times as great as McCarver, but this is not represented by the numbers on their respective uniforms. The numbers (or strictly speaking, numerals) assigned to each of these players serve only to identify the players.

Within the axiomatic theory of numbers, certain relations between and operations performed upon the elements of the set R^+ of positive real numbers are defined. As an illustration, the elements 1, 2, 3 of R^+, are in a definite relationship denoted by $1 < 2 < 3$. Also, an operation symbolized by + may be performed on the elements $1, 2 \in R^+$. The relation between the result of that operation and the element $3 \in R^+$ may be represented by $1 + 2 = 3$. If we are to use these relations and operations performed on elements of the set of positive real numbers to represent relations and operations performed on elements of a set A whose extension consists of sets of objects of experience, relations and operations must be interpreted as relations between and operations performed on elements of A.

To the element a we have assigned the number 1 and to the element b we have assigned the number 2. We saw that in R^+ the relation between 1 and 2 could be symbolized by $1 < 2$. But, for empirical science, the question is not what is the relation between the abstract entities in R^+. The question is what is the relation between a and b symbolized by $<$? Is there an observable relation symbolized by $\textcircled{<}$ between a and b such that $1 < 2 \Rightarrow a \textcircled{<} b$?

The symbol $<$ denotes an ordering relation between elements of R^+. What we must establish for the use of this symbol in empirical statements is an observable ordering relation between elements of A (the space of objects of experience) that is represented by the relation $<$. Just because there is a well-defined relation $<$ between elements of R^+, does not mean there is a corresponding relation $\textcircled{<}$ between elements of the space of objects of experience where these elements are represented by elements of R^+.

The relationship between elements of A symbolized by the relation $<$ between elements of R^+ that are in one-to-one correspondence with elements of A, conveys a significant amount of empirical information about elements of A. It implies, if the criterion of measurement has been met, that for any two elements of A such that the numbers assigned to these elements are in the relation $<$, then these objects of experience are in a definite observable relation denoted by $\textcircled{<}$. The ordering relation symbolized by $\textcircled{<}$ may however be represented by a different order preserving mapping. In our example, we might use a mapping $f: A \to R^+$ where under the mapping $f(a) = 2$, $f(b) = 5$,

$f(c) = 9$. If we had only defined an empirical ordering relation on A, no loss of empirical information would result from using the mapping f rather than the mapping g.

The use of the results of the operation + performed on elements of R^+, and the use of the results of this operation in empirical propositions about the elements of A, assumes not only the establishment of an ordering relation $<$ defined on A, but also assumes additional information. Precisely it assumes the establishment of an operation denoted by $+$ which when performed on elements of A is isomorphic to the operation + performed on the elements of R^+ used to represent elements of A.

The operation $1 + 2$ performed on elements of R^+ is a well-defined operation leading to a result $1 + 2 = 3$. However, for this operation to have any empirical content, we must define an operation denoted by $+$ which may be performed on elements of A. Under the mapping $g: A \rightarrow R^+$ we had $g(a) = 1$, $g(b) = 2$, $g(c) = 3$. The criterion of measurement involves the establishment and empirical confirmation of an operation that may be performed on a and b such that the performance of this operation denoted by $a + b$ leads to set of objects of experience that is represented by the positive real number 3. If we can satisfy this additive requirement of measurement, then the mapping $g: A \rightarrow R^+$ is invarient except under a linear transformation of the form $R^+ = xA$ where x is a constant. We cannot replace the mapping defined by g with the mapping defined by f without a loss of empirical information.

The process of empirical testing of a proffered hypothesis consists in performing a series of observations on objects of experience or on a series of data which represent objects of experience and/or performing well defined experimental operations on objects of experience or the performance of mathematical operations on data where the data represent objects of experience and the relations expressed by the mathematical symbols represent relations between sets of objects of experience and the mathematical operations are isomorphic to experimental operations that may be performed on the sets of objects of experience represented by the numerical data.

The assumption of measurement is fundamental to the empirical testing of economic hypotheses. Numbers and mathematical operations are useful to empirical testing if and only if the quantitative foundations of their use are securely established. The manipulation of numbers is not the goal of empirical science. If and only if we know what the numbers represent, what the relations represented by numbers tell us about the real world, and what operations performed on objects of experience are represented by numerical operations, can the use of mathematics function as a useful aid to empirical science.

Conclusions

We began our paper by assuming that the goal of policymakers was to make a rational decision. We defined a rational decision by policymakers as the choice of that set of attainable magnitudes of economic quantities most preferred by the policymakers. In order to make a rational choice, before taking a policy action, a policymaker is concerned to know the impact of such an action on the real world. To provide himself with such information, the policymaker frequently relies on his research staff and other economic advisors. Our paper was directed to the question of how such economic advisors could provide the policymaker with information on the basis of which he could make a rational decision.

At the present time, we operate under conditions of very imperfect knowledge about the economic system and the mechanisms by which the magnitudes of economic quantities are determined. At the start of our paper we set up the hypothetical case of two groups of policy advisors offering advice to a group of policymakers. We then stated that for the policy advice of either group to be of use to the policy-making group, the advisors would have to provide a link between what the advisors assert the policymakers should attempt to control, and some action they can perform on the elements of a definite set of objects of experience. As an example we took the group of policy advisors which asserted that the monetary authorities should control the growth rate of the money stock. They recommended that to control the growth rate of the money stock the Federal Reserve should perform the operation of purchase or sale of Government securities. Although the same requirement is placed on Group I, because of limitation of space, we did not discuss the procedure by which Group I would define an operation by which the Federal Reserve could lower the general level of market interest rates.

For the sake of illustration, let us assume that Group I would interpret this operation as purchase or sale of Government securities. This now opens the possibility of a conflict in the policy advice given to the monetary authorities. To achieve their goal of reducing the level of market interest rates, and hence their end goal of preventing a rise in the unemployment rate to 5 per cent, Group I might recommend that the monetary authorities buy Government securities making a net increase of $X million in their holdings of Government securities. Group II may recommend that to achieve their goal of keeping the growth rate of the money stock below 4 per per cent, and hence achieve their end goal of preventing the consumer price index from rising at a 4.5-5.5 per cent rate, that the monetary authorities should sell $Y million of Government securities. The monetary authorities are now faced with a decision,they cannot at the same time make a net increase in their holdings of Governments and a net decrease in their holdings of Governments.

In our hypothetical example the persons charged with making a policy decision are faced with a difficult decision. If they buy Governments then Group II advises them they will observe a rapid rate of inflation. If they sell Governments, then Group I advises that they will observe a sharp rise in the rate of unemployment. All that we require in our paper is that the policymakers make a rational decision.

If we lived in a Camelot of perfect knowledge about the economic system, the process of making their rational decision would be much easier for the policymakers. We do not live in such an ideal state of knowledge, the conclusions of the arguments of the two groups of policy advisors are conditional upon the truth values assigned to the premises of their arguments. The policymakers must therefore also carefully assess the evidence each group of advisors offers for their premises. We listed three questions the policymakers might pose to any economic advisor. We outlined a framework by which economic advisors could attempt to provide an answer to these questions, and hence aid the policymaker in making his rational decision.

The framework of scientific exploration we have outlined is not a sure, quick, and golden path to knowledge. Our only claim is that by this method, taking into account such fundamental conditions as the criterion of measurement, the statement of initial conditions, and the careful testing of well-defined hypotheses, the economist would be able to advise policymakers that if they performed a definite operation on a definite set of objects of experience, they could expect to observe a definite change in a segment of the real world. Also, each group of proponents of a policy recommendation could show the evidence they have for such asserted propositions. Hopefully, by carefully stating each hypothesis and by exposing it to repeated testing by other economists, each proposed explanation offered policymakers would be fully exposed to refutation by empirical testing.

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